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For: METHOD FOR PREGOBING AN OPTICAL FIBER PREFORM AND SYSTEM  
PRODUCING OPTICAL FIBER THEREFROM

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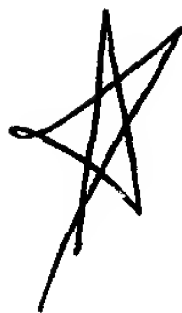
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**METHOD AND APPARATUS FOR THE THERMAL TREATMENT OF AN  
OBJECT SUCH AS AN OPTICAL FIBER PREFORM**

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**Related Applications**

The invention claims priority to German Patent Application having an official  
file number of 19914507.5 (GR number 99P1555 DE) filed March 30, 1999.

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**Field of the Invention**

The invention relates to methods and apparatus for manufacture of optical fiber  
preforms and optical fiber.

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**Background**

The starting point of the method for the production of an optical fiber, which  
consists of a core (refractive index  $n_1$ ), a cladding (refractive index  $n_2 < n_1$ ) that  
surrounds the core concentrically, and a protective plastic layer (single or multi-layers  
"coating"), and which is used in communications cables as an optical transmission  
element, is an elongated, cylindrical quartz glass body, doped in accordance with the  
profile of the desired refractive index. This so-called "preform" is introduced very  
slowly, by means of a feed device, into the heating chamber of a high-temperature  
furnace, placed in the upper part of the fiber drawing tower, and heated. At  
temperatures  $T > 2000^\circ$ , the conically tapering tip of the preform is gradually  
transformed to a state of honey-like consistency, until finally a glass strand melts off,  
which consists of a core and cladding. After the quartz glass that is not suitable for the  
fiber production drips off, the so-called "draw bulb" is formed under the influence of

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gravity. The conically tapering transition area between the quartz glass cylinder and the drawn-off fiber, whose form and dimensions depend on the high-temperature furnace and the individual drawing conditions, is referred to as the draw bulb. The glass strand of a diameter of approximately 125  $\mu\text{m}$ , which is continuously drawn off from the preform, then passes through the coating system, which applies the protective sheath (coating) and is located in the drawing tower directly below the diameter testing device, so that finally the fiber is placed on a supply drum and stored temporarily.

After a length of optical fiber, which is dependent on the size or mass of the preform, is drawn, the production must be interrupted and the consumed preform must be replaced by a new one. Frequently, more than one hour elapses until the production of fiber with the required characteristics resumes. During this start-up time, the dripping off of the quartz glass mass that cannot be used takes place as well as the shaping of the draw bulb that satisfies the drawing conditions. The shaping of the draw bulb alone takes approximately 30 to 40 minutes.

### Summary of the Invention

The invention concerns an apparatus and method, in particular a heating furnace and method, for the thermal treatment of an object made of a high temperature-stable material, such as quartz glass of an optical fiber preform. The apparatus in accordance with the invention permits, for example, the quartz glass mass of an optical fiber preform that is not suitable for fiber drawing to melt off more rapidly than in a conventional furnace without contaminating the preform with foreign particles during this process. Moreover, since preforms including pre-optimized draw bulbs are provided which are already appropriately melted off at the tip, the downtime of an optical fiber drawing apparatus can be considerably shortened.

In accordance with the invention, both the heating chamber, which has good heat insulation, and the  $\text{H}_2/\text{O}_2$  gas burners of the heating furnace, which fire through lateral heating chamber openings onto the preform, are made of quartz glass. Thus, these elements can withstand the temperatures that are generated in the chamber and that reach maximum values of  $T$  of about  $2500^\circ\text{C}$  in the area of the preform tip, without damage for a longer period of time. With 15-30 kW, the heating capacities of the gas burners are dimensioned in such a way that the tip of the preform, which rotates about its longitudinal axis, melts off in a drop already after approximately 20 minutes and the typical draw bulb is formed. In order to optimize its shape, the preform and/or the burners can be shifted in a vertical direction, relative to one another, according to a preset program.

5 A contamination of the preform with foreign particles during the melting of the quartz glass mass is extensively ruled out since the combustion gases escape from the heating chamber with excess pressure (dirt does not enter due to the so-called chimney effect) and in any case,  $\text{SiO}_2$  particles precipitate on the preform. A slight cooling of the heating furnace may be required to the same degree as a flushing of the heating chamber with a protective gas.

10 In accordance with another aspect, the invention is method for treatment of a glass article, comprising the steps of heating one end of an optical fiber preform to form a draw bulb on the end of the preform, and then transferring the preform to a drawing tower wherein an optical fiber may be drawn therefrom. According to a preferred aspect of the invention, a quartz glass mass is melted off of the preform that is not suitable for fiber drawing. Preferably also, the preform is rotated while heating.

15 In accordance with another aspect, the invention is method for treatment of a glass preform, comprising the step of, prior to drawing, and in a heating chamber separate from a draw chamber of a draw unit, forming a pretreated preform having a draw bulb sufficient to reduce downtime of the draw unit. Preferably, the draw bulb of the preform is formed at a temperature of greater than  $1800^\circ\text{C}$ .

20 By using appropriately pretreated preforms, that is, preforms that have optimized draw bulbs, which have already melted off at the tip, it is possible to advantageously reduce the down time of a glass fiber drawing unit by up to 15-30 minutes per replaced preform. In particular, since the high temperature draw furnace of the drawing tower needs to melt less quartz glass mass this results in shorter heating-up and internal heating times. Further, the transition phase between the melting and the fiber drawing takes considerably less time at the theoretical rate (the main time savings) thus the draw towers are in operation more of the time. This particularly true when the draw bulb is produced off-line in a separate heating furnace. Also, it is not necessary to move the preform as deep into the high temperature furnace (time savings because of the generally low feed rate).

### 30 Brief Description of the Drawings

The invention is further explained below with reference to the accompanying drawings.

35 Fig. 1 illustrates a cross-sectioned side view of an embodiment of a heating furnace for the thermal treatment of a preform in accordance with the invention.

Fig. 2 illustrates a cross sectional view of the heating furnace of Figure 1, taken along the line A-A.

Fig. 3 is a top cross sectional view illustrating the temperatures attained within the heating furnace during the operation.

Fig. 4 illustrates a top partially sectioned view of the structure of a quartz glass burner in accordance with the invention.

Fig. 5 and 6 illustrate various schematic top views the holder of the quartz glass burner in accordance with the invention.

Fig. 7 illustrates a flow diagram of the method steps in accordance with the invention.

#### Detailed Description of the Preferred Embodiment

The heating furnace 1, shown schematically in Figures 1 and 2, is used for the melting off of the quartz glass mass of the preform 2, that is not suitable for the fiber drawing. This furnace 1 is preferably a separate unit from the draw tower and is used to produce the draw bulb 30 on the preform, such that when it is transferred to the draw tower, the time needed to commence drawing is reduced. This reduction is due to the draw bulb having already been formed in the previous heating furnace. Essentially, the heating furnace 1 has a cylindrical heating chamber 3-5, heat insulation 6-9 surrounding the heating chamber 3-5 on all sides, several gas burners 12-13 firing onto the preform 2 through lateral heating chamber openings 10-11, and a frame, which fixes the aforementioned components and has of steel or aluminum groove profiles 14, which are square in cross-section and screw into one another. Since the  $\text{SiO}_2$  preform 2 softens only after a temperature  $T$  of about  $1750^\circ\text{C}$ , an appropriately high temperature ( $T \geq 1800^\circ\text{C}$ ) must be generated in the furnace space, so both the heating chambers 3-5 as well as the flame-producing components (burner tube, nozzles) of the gas burners 12-13 are made of a high temperature-stable material, in particular, quartz glass, which expands longitudinally only slightly during heating. Further, the use of quartz glass has the advantage that there is no contamination of the preform 2 with foreign particles and, at most,  $\text{SiO}_2$  particles are precipitated.

The heating chamber 3-5 preferably has a cylindrical  $\text{SiO}_2$  middle part 3 (a height  $h$  of approximately 470 mm, radius of about 180 mm, and wall thickness  $d$  of about 30 mm), that is provided with the gas burner openings 10-11 (with a diameter of



about 80 mm), and two quartz glass lids 4/5, which are hexagonal and whose edge projections are adapted to the placement configuration of the heating furnace. The preform 2 (includes a diameter between about 40-120 mm), which is already preferably preheated to a temperature  $T$  in the range of between about  $600^{\circ}\text{C}$  –  $800^{\circ}\text{C}$  in a separate heating furnace, is introduced through a circular opening 15 of the upper lid 4 into the heating chamber 3-5 and is moved downwards until the conically tapering tip of the preform 2 is in the plane defined by the burner openings 10-11. The quartz glass dripping off from the preform 2, which rotates about its longitudinal axis, arrives at a collecting apparatus, which is not depicted, through a circular opening 16 of the lower heating chamber lid 5.

The upper and the lower heating chamber openings 15-16 have a common symmetrical axis 17, which is oriented parallel to the heating chamber longitudinal axis 18 and is shifted laterally (offset) with respect to it, in the direction of the gas burners 12-13. The axis distance designated with  $\Delta t$  in Figure 2 is dimensioned hereby in such a way that the preform 2 is located in the hottest point of the flames and its distance to the adjacent heating chamber wall is still sufficiently large. At the same time, the preform 2, situated in this manner, prevents the direct firing of the heating chamber wall, opposite the gas burners 12-13, which considerably reduces its thermal load. In the hottest point of the flame, adjacent to the position of the preform, the temperature reaches a value  $T$  of about  $2500^{\circ}\text{C}$  (See Figure 3); in the rest of the interior chamber of the furnace—that is, outside the flames, the temperature reaches a value of  $T = 1600$ - $1800^{\circ}\text{C}$ . With values around  $T = 1400^{\circ}\text{C}$ , the maximum temperature measured at the outer chamber wall is sufficiently low so as to ensure a high service life of the heating furnace.

The heating capacity of the gas burners 12-13 is a of maximum 60 kW during operation, and more typically approximately 20-30 kW. The gas burners 12-13 are supplied with hydrogen and oxygen gases, which are conducted separately to the burners 12-13 via two  $\text{O}_2$  connections ("outer" and "inner" oxygen) and an  $\text{H}_2$  connection (See Figures 2 and 4). As Figure 4 shows, the outer oxygen is conducted to the burner tip via an annular nozzle 21, which is formed by the two cylindrical parts 19-20 of the gas burners 12-13. The inner oxygen is conducted into several flat nozzles 23,23',23" that are oriented parallel and located in the center of the burner head 22; and the hydrogen is conducted into the space between the flat nozzles 23,23',23" and the cylindrical part 20. As already mentioned, all components of the gas burner are made of quartz glass.

The holder of the gas burner 12,13 depicted in Figures 5 and 6 is comprised of an upper part 24 and a lower part 25 that are connected in a detachable manner to the

upper part 24, between which the gas burner 12,13 is firmly clamped or, by means of loosening a screw connection, can be guided in the direction of the double arrow. In order to be able to orient the gas burner 12,13 with respect to the preform 2, the holder is connected via a rack, which has several groove profiles 26,27 and elbows 28,29, to the frame 14 of the heating furnace. Since the holder 24,25 is also supposed to protect the silicone hoses, which bring the hydrogen and the oxygen to the corresponding burner connections, from the heat radiation of the heating furnace, it is made of a material with good heat insulation, in particular, a mixture of mica lamellae, moscovites, phlogopite, and silicone resin.

The heat insulation 6-9 surrounds the heating chamber walls 3-5 of the heating furnace 1 on all sides (see Figures 1 and 2). In the embodiment example shown, the insulation has a middle part 6,7 which forms a hexagon, and two plate-like lids 8,9 provided with recesses 15',16'. The two lids 8,9 (having a thickness of about 20 mm) are preferably made of quartz glass. The corresponding plate-like elements of the middle part 6,7 have a thickness of about 30 mm and are made of a fireproof and oxidation-resistant insulating material that has low thermal conductivity, in particular, glass fiber or ceramic fiber material. One particularly suitable material, for example, has the tradename DOTHERM<sup>TM</sup> by DOTHERM - Isolierwerkstoffe, 44293 Dortmund, which contains the essential components of calcium silicates, special portland cements, carbon microfibers, organic fibers, and mineral binders and additives. Depending on the type, these insulating materials, which can be processed with normal hard metal tools and can be supplied in the form of plates in different sizes and thicknesses, can also withstand temperatures  $T > 1000^{\circ}\text{C}$  (DT 1100 and DT 1200). Their thermal conductivity is about 0.114 (DT 1100) or 0.08 W/mK (DT 1200). The heat insulation 7' (preferably DT 1100), located between the gas burners 12,13 serves to protect the personnel during the loading of a preform 2 into the heating furnace 1.

In operation, as best described in Fig. 7 is illustrated in the flow chart of the method in accordance with the invention, the preform 2 is first preferably preheated to between about  $600^{\circ}\text{C}$  and  $800^{\circ}\text{C}$  in step 1 labeled 31. The preform 2 is then inserted into the heating furnace 1 in step 2 labeled 32. Within the heating chamber 3-5 as described in step 3 labeled 33, the preform 2 is heated as heretofore described to form a draw bulb 30 thereon. After this, the pretreated preform having a draw bulb 30 formed thereon is transferred to a draw furnace of a draw tower as described in step labeled 34.

The draw bulb 30 formed on the end of the preform 2 is sufficient to reduce the resultant draw time required to draw a fiber from the preform in step labeled 35. In particular, if the draw bulb 30 is preoptimized, in that it is shaped appropriately to

facilitate faster draw fiber therefrom, the time savings during the draw process may be 30-50 minutes.

It will be apparent to those of ordinary skill in the art that various modifications and variations can be made to the present invention without departing from the scope of the invention. For example, it is readily possible to equip the heating furnace 1 with only one  $H_2/O_2$  burner of an appropriate capacity, or also with more than two burners, wherein the lateral burner openings should be located in the lower half, in particular, in the lower third of the heating chamber. Optionally, for example, the burners may be appropriately adapted to operate with other combustible gases also, in particular, with natural gas, acetylene, butane, methane, or propane. Furthermore, the diameter of the openings 15,16, in the upper and in the lower heating chamber lids 4,5 may be selected so that they are up to 100% larger than the cross sectional area of the preform 2. Furthermore, in some cases, the openings 15, 15', 16, 16' may be other than circular, i.e., adapted to the shape of the material to be treated. The burners may optionally be situated such that the burner axes 12'/13' are positioned at an angle that differs from  $90^\circ$ , relative to the longitudinal axis 17' of the preform 2. Further yet, it may be advantageous to provide a non-cylindrical heating chamber 3. Moreover, other high temperature-resistant ceramic material may be employed instead of quartz glass. Additionally, the design of the lid, insulation, and rack may be round or other suitable shapes. Thus, it is intended that the present invention cover the modifications and variations provided they come within the scope of the appended claims and their equivalents.



### Claims

What is claimed is:

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1. Apparatus for the thermal treatment of an object (2), comprising:

(a) a thermally insulated heating chamber (3-5), whose walls include an upper opening (15) which is used to introduce the object (2) into the heating chamber (3-5), an exit opening (16), which is opposite the upper opening (15), and at least one lateral opening (10,11); and

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(b) at least one burner unit (12, 13), whose flame is used to heat the object (2) and fires onto the object (2) through the lateral opening (10, 11) of the wall.

2. The apparatus according to Claim 1, further comprising a common

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symmetrical axis (17) of the upper opening (15) and the exit opening (16) that is displaced laterally in the direction of the lateral opening (10, 11), relative to a longitudinal axis (18) of the heating chamber, the longitudinal axis (18) being oriented parallel to the common symmetrical axis (17).

3. The apparatus according to Claim 1 wherein the heating chamber (3-5)

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includes a middle part (3) provided with the lateral opening (10-11), and the middle part (3) is made of a material which exhibits a melting temperature above about 1500°C and whose coefficient of thermal expansion is smaller than  $10^{-6}$  per °C.

4. The apparatus according to Claim 3 wherein the middle part (3) of the heating chamber and at least one element (20, 22) of the burner unit (12, 13) are made of the same material.

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5. The apparatus according to Claim 4 wherein the middle part (3) of the

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heating chamber and the element (20, 22) are made of quartz glass or ceramic.

6. The apparatus according to one of Claim 3 wherein the middle part (3) of the heating chamber is closed off at the end, by two plate-like elements (4, 5) provided with the upper opening (15) and the exit opening (16), respectively.

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7. The apparatus according to Claim 6 wherein the plate-like elements (4, 5) and the middle part (3) are made of the same material.

8. The apparatus according to one of Claim 1 wherein a dimension of the upper opening and the exit opening (16) are at most 100% larger than the maximum diameter of the object (2).

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9. The apparatus according to one of Claim 3 characterized in that the middle part (3) has a cylindrical shape.

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10. The apparatus according to one of Claim 1 further comprising several burner units (12, 13), whose flames fire onto the object (2) through a lateral opening (10, 11) of the heating chamber (3-5).

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11. The apparatus according to Claim 10 wherein the lateral openings (10, 11) in the lower half of the heating chamber (3) corresponding to the burner units (12, 13) are located in a plane, which is oriented approximately vertical to a longitudinal axis (18) of the heating chamber in the areas of a chamber wall close to the object.

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12. The apparatus according to Claim 1 wherein the burner unit (12, 13) operates on  $H_2/O_2$ , natural gas, acetylene gas, butane gas, methane gas, or propane gas.

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13. The apparatus according to Claim 1 wherein the burner units (12,13) or a flame-producing elements (20, 22) therein are oriented to the symmetrical axis (17), which is defined by the upper opening (15) and the exit opening (16) and is laterally displaced relative to a longitudinal axis (18) of the heating chamber.

14. A method for treatment of an optical fiber preform (2), comprising the steps of:

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a) heating one end of an optical fiber preform (2) to form a draw bulb (30) on the end of the preform (2), and

b) transferring the preform (2) to a drawing tower wherein an optical fiber may be drawn therefrom.

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15. The method of claim 14 further comprising melting a quartz glass mass off of the preform (2) that is not suitable for fiber drawing.

16. The method of claim 14 further comprising rotating the preform (2) while heating.

5 17. The method of claim 14 wherein the step of heating is accomplished by at least one gas burner (12 or 13) firing onto the preform (2).

18. The method of claim 17 wherein the step of heating is accomplished by a plurality of gas burners (12, 13) firing onto the preform (2).

10 19. The method of claim 14 wherein the step of heating is accomplished by flames which fire onto the preform (2) through a lateral opening (10 or 11) in the heating chamber.

15 20. The method of claim 14 further comprising preheating the preform (2) prior to inserting the preform (2) into the heating chamber (3-5).

20 21. The method of claim 14 wherein prior to the heating step, the preform (2) is inserted into a heating chamber (3-5) by passing the preform (2) through an upper opening (15) of a plate-like element of the heating chamber (3-5).

22. A method for treatment of a optical fiber preform, comprising the step of:  
prior to drawing, and in a heating chamber (3-5) separate from a draw chamber of a draw unit, forming a pretreated preform (2) having a draw bulb (30) sufficient to reduce  
25 downtime of the draw unit.

23. The method of claim 22 further comprising melting a quartz glass mass off of the preform (2) that is not suitable for fiber drawing within the heating chamber (3-5).

30 24. The method of claim 22 further comprising forming the draw bulb (30) at a temperature of greater than 1800 °C.

**Abstract**

5       An apparatus and method for the thermal treatment of an object, such as a glass  
optical fiber preform. The downtime of an optical fiber drawing apparatus can be  
considerably shortened, by providing preforms which have pre-optimized draw bulbs  
(30). Pre-optimized draw bulbs (30) are provided which are already appropriately  
melted off at the tip. A heating furnace (1) is used for such thermal pretreatment (pre-  
optimization) of the preforms (2) and which does not contaminate the quartz glass.  
10       Utilizing preforms (2) which have pre-optimized draw bulbs advantageously increased  
throughput of the draw apparatus. In accordance with one embodiment, a heating  
furnace (1) that meets these requirements includes a cylindrical heating chamber (3-5),  
heat insulation (6-9) surrounding the heating chamber on all sides, several gas burners  
(12-13) firing onto the tip of the rotating preform (2) through lateral heating chamber  
15       openings (10-11), and a frame (14). Since the preform (2) softens after a temperature of  
about  $T > 1750^{\circ}\text{C}$ , correspondingly high temperatures must be generated in the heating  
chamber (3-5). Therefore, both the heating chamber (3-5) and the gas burners (12-13)  
are made of quartz glass or a ceramic material.

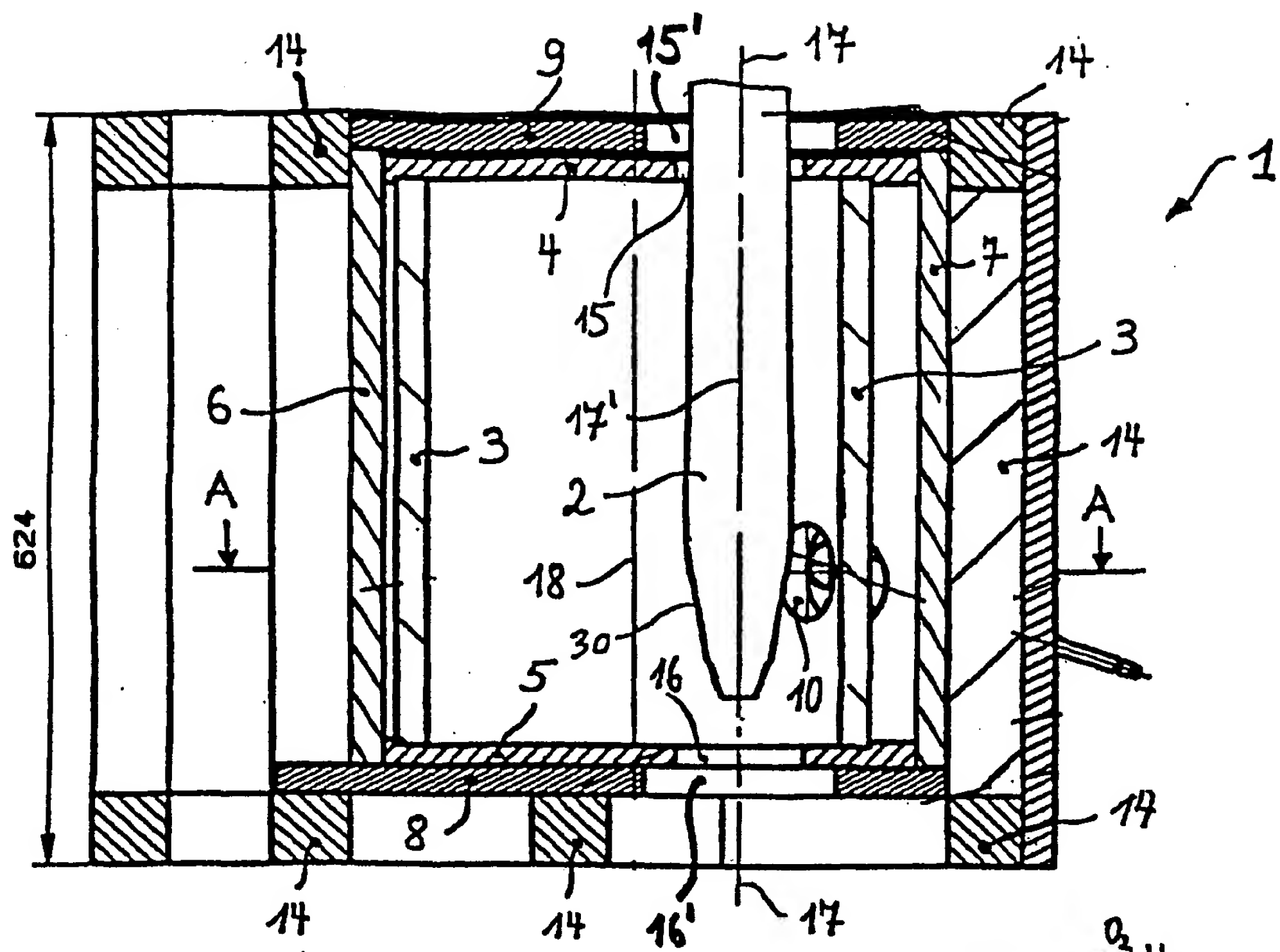


Fig. 1

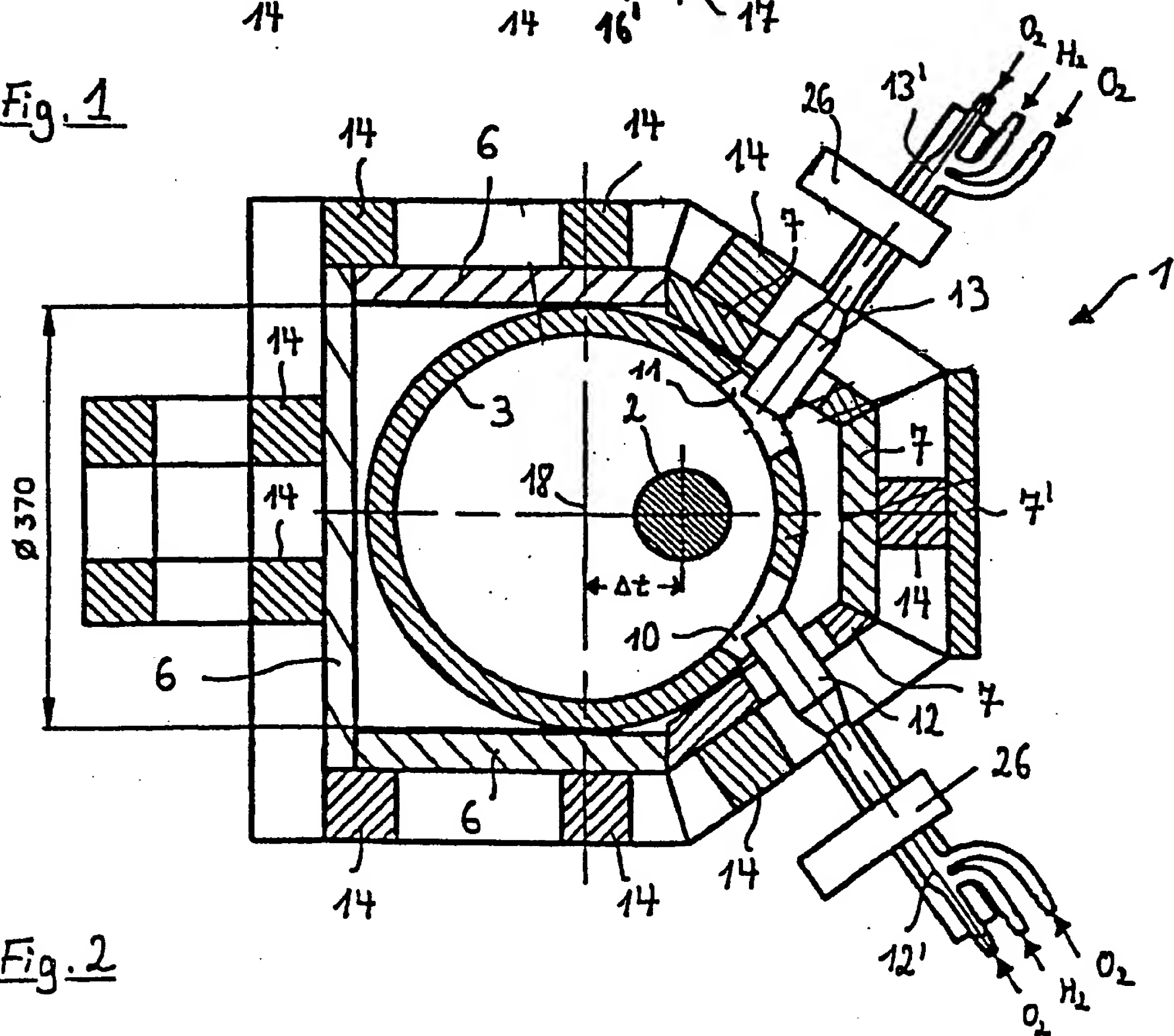


Fig. 2



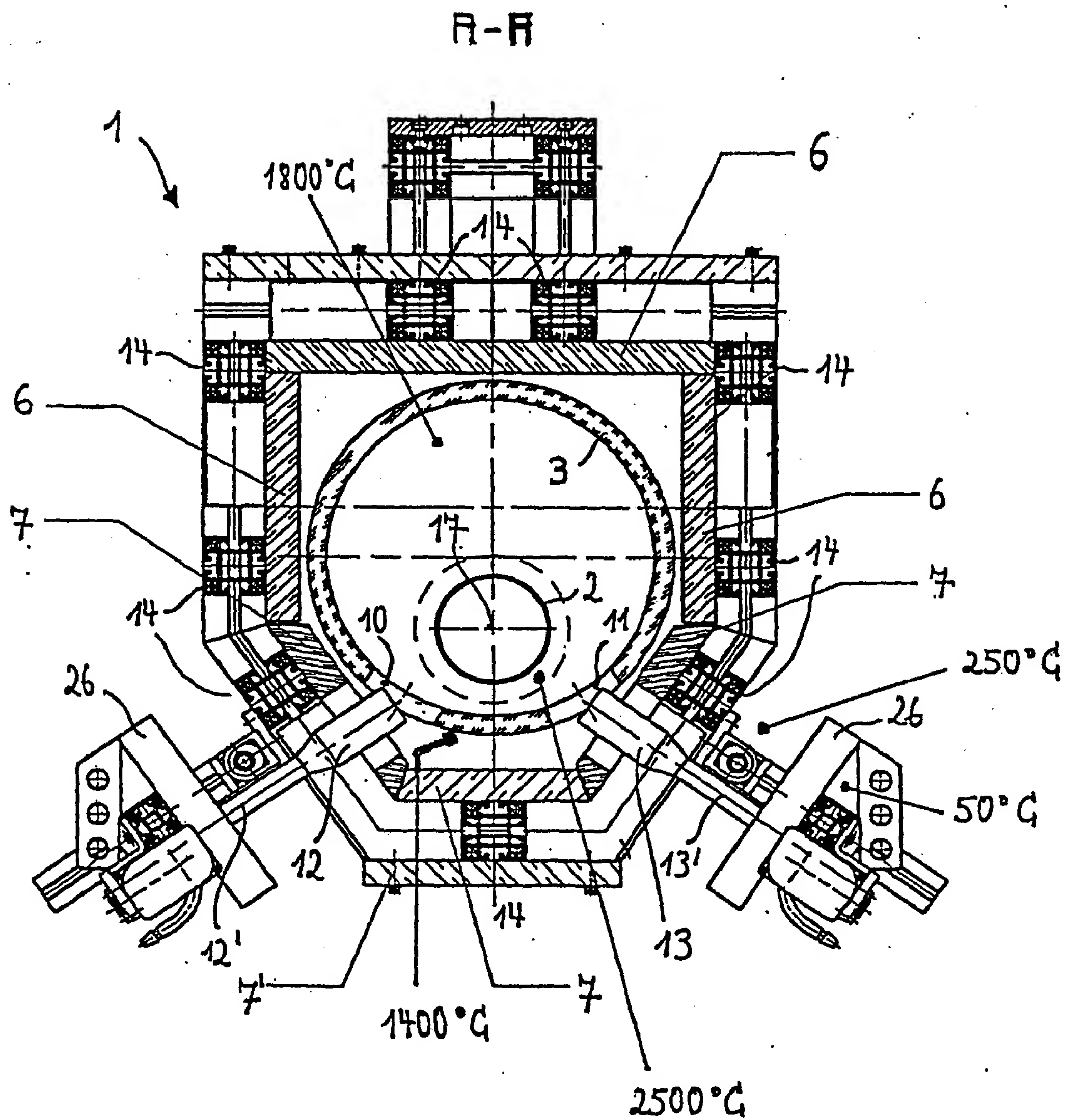


Fig. 3



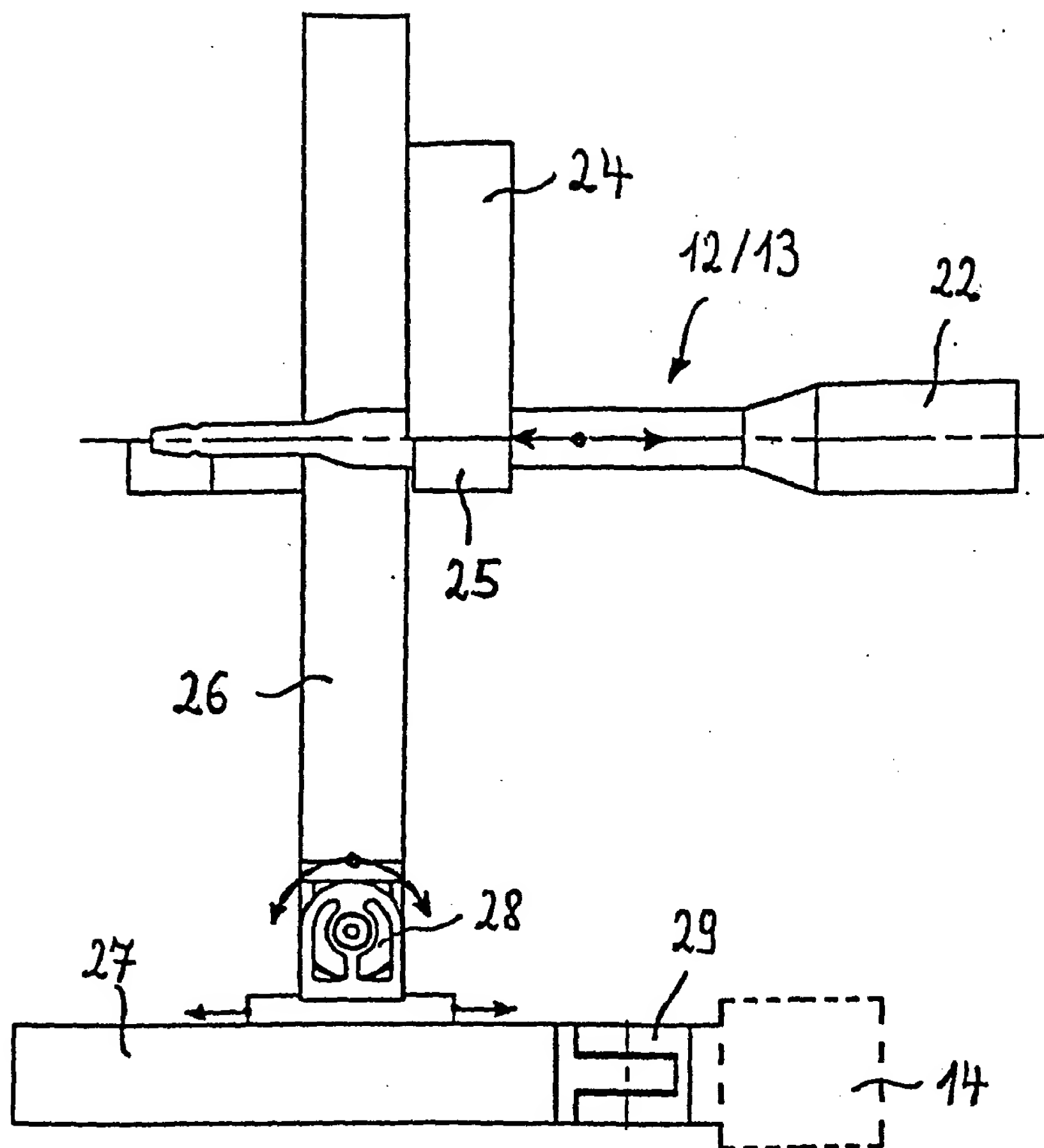


Fig. 5

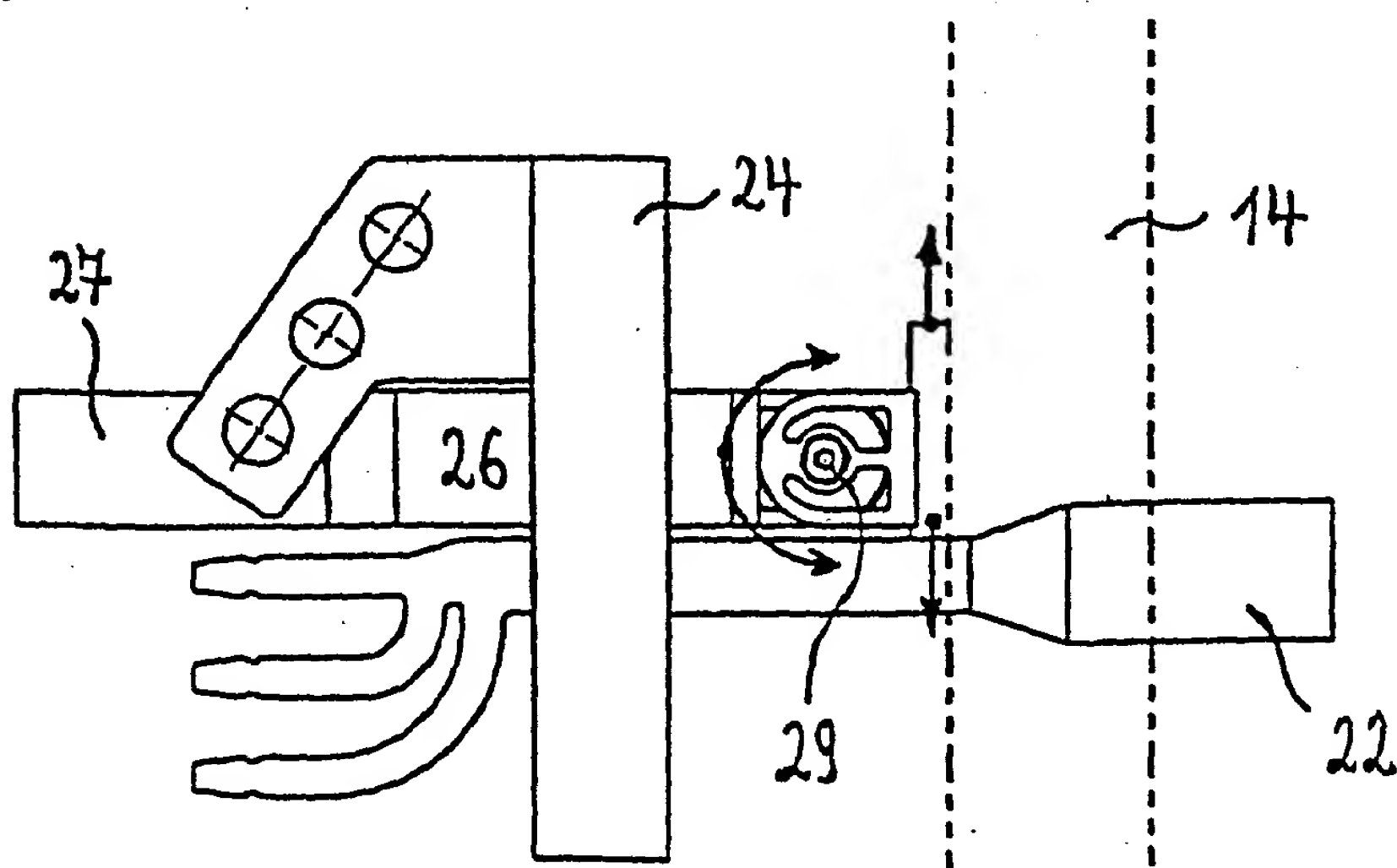


Fig. 6

Fig. 7

